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(54) **Sole units for footwear**

(57) A sole unit 10 is adapted to store the energy potential resulting from the heel striking the ground and to release the energy to facilitate forward propulsion of the walker. The sole unit contains a first chamber 11 in the heel, a second chamber 12 disposed under the metatarsal heads of the foot, a passage 19 extending from chamber 11 to chamber 12 and containing a non-return valve 21, a substantially undeformable reservoir 20 and a trigger valve 22. An exhaust passage 15 extends from chamber 12 to atmosphere via a trigger valve 18. An inlet passage 13 leads from atmosphere to the first chamber and contains a non-return valve 14. When the heel strikes the ground, air from chamber 11 is forced by the resilient contraction of chamber 11 through valve 21 into reservoir 20. Valve 22 is normally closed but opens to admit the air from reservoir 20 to chamber 12 to lift the wearer when his weight comes fully on to the metatarsal heads. The air is released from chamber 12 through passage 15 when the wearer's weight is on valve 18 just prior to the weight moving on to the metatarsal heads. An arrangement is also described in which the air moves in a closed circuit.

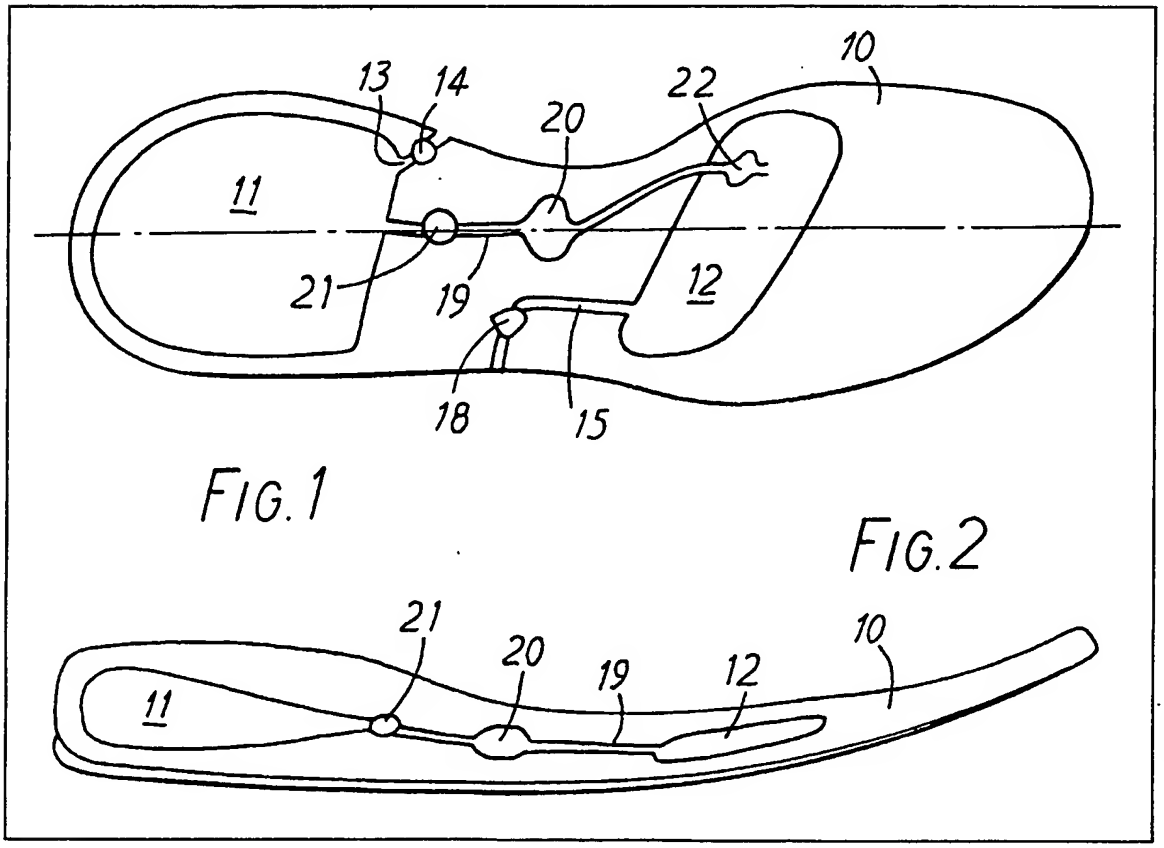


FIG. 1

FIG. 2






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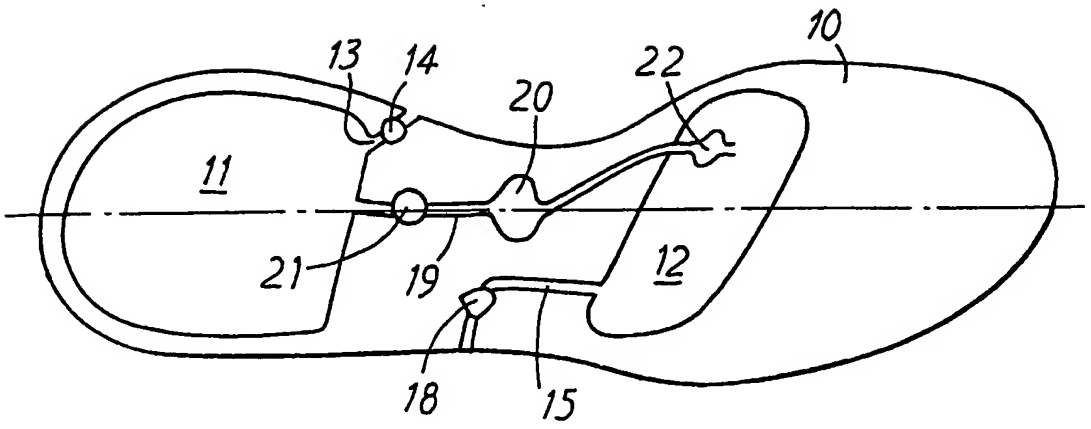



FIG. 1

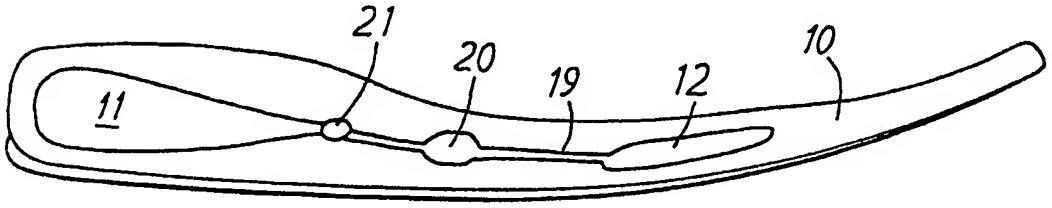



FIG. 2

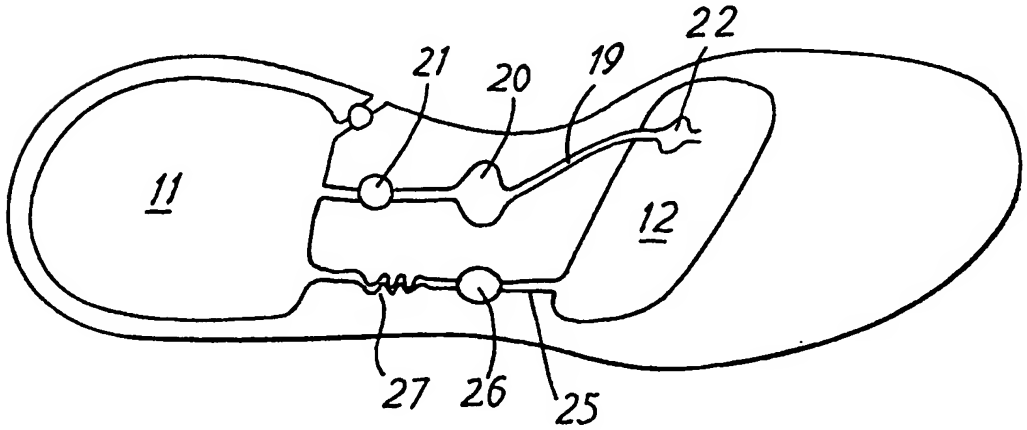



FIG. 7

FIG.3

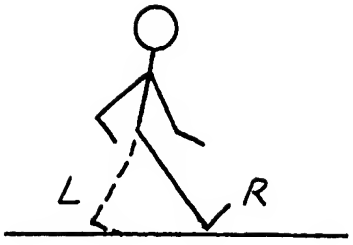



FIG.4

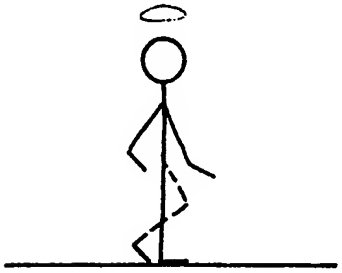


FIG.5

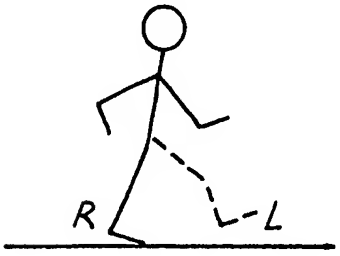
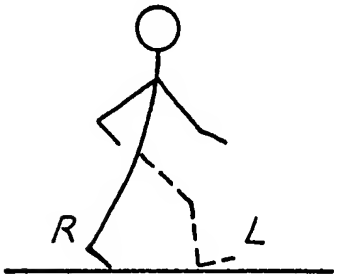



FIG.6



SPECIFICATION

**Improvements relating to sole units for footwear**

This invention relates to sole units for footwear.

According to this invention there is provided a sole unit formed with a first chamber in the heel, a second chamber which is disposed in the region of the metatarsal heads of the foot and which is resiliently expansible, the heel of the unit being adapted to be resiliently deformed to reduce the volume of said first chamber when the weight of the wearer is placed on the heel in walking, a first passage for carrying air from said first chamber via a non-return valve to a substantially inexpansible reservoir space and thence via a trigger valve to said second chamber, said trigger valve being normally closed but being opened by the weight of the wearer when such weight is placed on the metatarsal heads, valve means adapted and arranged to allow a delayed discharge from the second chamber of air released from the reservoir into the second chamber by operation of the trigger valve, and means for re-admitting air to the first chamber on removal of the weight of the wearer from the heel.

The invention also provides a sole unit formed with a first chamber in the heel, a second chamber which is disposed in the region of the metatarsal heads of the foot and which is resiliently expansible, the heel of the unit being adapted to be resiliently deformed to reduce the volume of said first chamber when the weight of the wearer is placed on the heel in walking, a first passage for conveying gas from said first chamber via a non-return valve to a substantially inexpansible reservoir space and thence via a trigger valve to said second chamber, and passage means through which gas can escape from the second chamber by way of an outlet valve and through which gas can be drawn into said first chamber, on removal of the weight of the wearer from the heel, by way of a non-return valve and a restrictor arranged in series, said trigger valve being adapted and arranged normally to be closed but to permit gas to flow through the first passage from said reservoir to the second chamber when the weight of the wearer is placed on the metatarsal heads of the foot.

Two embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

*Figures 1* and *2* are respectively sectional plan and sectional elevations of a first sole unit according to the invention,

*Figures 3* to *6* respectively illustrated the sequence of events in operation of the sole unit, and

*Figure 7* is a sectional plan view of a second sole unit according to the invention.

The purpose of embodiments to be described is to provide assistance to walking effort by storing the energy potential of heel strike until the moment immediately prior to take off, when that energy is released to facilitate forward propulsion.

In normal walking, one leg is swung forwards to place the centre of gravity of the body in front of the supporting leg. This then allows the mass of the body to "topple" onto the newly placed limb. The body is now supported momentarily on two limbs, and forward momentum is maintained only by pushing off with the trailing limb and swinging it forward to complete the cycle.

A studt if the force vectors shows that the main component is the vertical one, with a much smaller force being exerted either in the direction of movement (trailing leg) or against it (leading leg). The greatest forces, therefore, exerted on the body during walking are to raise the centre of gravity immediately prior to the swing phase, and to arrest its descent during the heel strike phase.

The illustrated arrangements providei a means of utilising the falling mass of the body at heel strike to compress air (or gas) via a simple displacement "pump". The compressed air is stroed in a distortion-free chamber until the full weight of the body is centred above the first metatarsal head of the foot. A trigger valve then releases compressed air into the area under the metatarsal heads to provide lift.

Referring to Figures 1 and 2, a sole unit 10 is shown which has a first chamber 11 in the heel portion, a second chamber 12 in the part of the sole underlying the metatarsal head region of the foot, an air inlet passage 13 extending to the chamber 11 from the ambient atmosphere and containing a non-return valve 14, an exhaust passage 15 leading from chamber 12 to the ambient atmosphere and containing a trigger valve 18, and a passage 19 for conveying air from chamber 11 to a substantially inexpansible intermediate chamber or reservoir 20 and thence to the second chamber. A non-return valve 21 is disposed in passage 19 between chamber 11 and the reservoir 20, and a trigger valve 22 which is normally closed prevents air from flowing from passage 19 into the chamber 12 but is triggered to open the valve when the weight of the wearer comes on to the metatarsal heads region of the sole unit. The chambers 11 and 12 are covered at the bottom of the sole unit by portions of the unit which are capable of resilient movement to expand and contract the volumes of the two chambers.

Figures 3 to 6 illustrate the operation of the sole unit as the wearer walks, the right and left legs being shown in full and broken lines respectively. In Figure 3 the heel of the right foot is shown hitting the ground, causing the first chamber 11 to contract and force the air therein through the non-return valve into the reservoir. Trigger valve 22 is at this time closed. As the wearer's weight comes squarely on to the right foot (Figure 4) the trigger valve 18 is actuated allowing the air which is under pressure in the second chamber 12 to pass to atmosphere through passage 15. At this stage also, chamber 11 is beginning to expand and to draw air into itself through passage 13 and valve 14. As the right heel lifts from the ground (Figure 5) chamber 11 is full of air, and the pressure trigger valve 18 has become insufficient to maintain the valve open, so it closes and exhausting air from chamber 12 ceases. The pressure on trigger valve 22 is increasing and as the heel of the left foot approaches its striking point the pressure on the trigger valve 22 actuates opening of the valve causing the air compressed in the reservoir

to flow into chamber 12, imparting a lifting pressure to the trailing right leg. The sequence of events is repeated with the left foot as it approaches its strike point.

Figure 7 shows an alternative arrangement which employs a closed-circuit movement of the air instead of the open-circuit arrangement of Figures 1 and 2. Thus instead of the separate inlet and outlet passages 13, 15 with their associated valves 14, 18 a passage 25 extends from chamber 12 to chamber 11 and contains a non-return valve 26 and a restrictor 27. The system is initially filled with air at a gauge pressure of 1.4 to 2.8 Kg/sq.cm. (2 to 4 lb/sq.in). The operation is substantially as described in relation to Figures 1 and 2, valve 26 and restrictor 27 together allowing chamber 11 to refill without losing the lifting effect of the surge of air released into chamber 12 by the actuation of trigger valve 22.

In one form the trigger valve comprises a resilient but stiff, substantially flat circular housing having an internal annular partition spaced between its top and bottom walls. A disc lightly loaded by a spring against the underside of the partition divides the interior of the housing into two spaces which are sealed from each other, the spaces below and above the partition communicating respectively with the reservoir 20 and chamber 12. A projection is mounted on the underside of the top wall of the housing opposite the centre of the disc. The top wall deflects under the weight of the wearer centred above the first-mentioned head of the foot and causes the projection to engage the disc and lift it away from the partition so that the air under pressure in the reservoir is released into the chamber 12.

## CLAIMS

1. A sole unit formed with a first chamber in the heel, a second chamber which is disposed in the region of the metatarsal heads of the foot and which is resiliently expansible, the heel of the unit being adapted to be resiliently deformed to reduce the volume of said first chamber when the weight of the wearer is placed on the heel in walking, a first passage for carrying air from said first chamber via a non-return valve to a substantially inexpansible reservoir space and thence via a trigger valve to said second chamber, said trigger valve being normally closed but being opened by the weight of the wearer when such weight is placed on the metatarsal heads, valve means adapted and arranged to allow a delayed discharge from the second chamber of air released from the reservoir into the second chamber by operation of the trigger valve, and means for re-admitting air to the first chamber on removal of the weight of the wearer from the heel.

2. A sole unit as claimed in claim 1, wherein said means for re-admitting air to the first chamber comprises a passage opening at its two ends to the first chamber and atmosphere respectively and a non-return valve arranged to permit air to flow through the passage into the first chamber but not in the reverse direction.

3. A sole unit formed with a first chamber in the heel, a second chamber which is disposed in the region of the metatarsal heads of the foot and which is resiliently expansible, the heel of the unit being adapted to be resiliently deformed to reduce the volume of said first chamber when the weight of the wearer is placed on the heel in walking, a first passage for conveying gas from said first chamber via a non-return valve to a substantially inexpansible reservoir space and thence via a trigger valve to said second chamber, and passage means through which gas can escape from the second chamber by way of an outlet valve and through which gas can be drawn into said first chamber, on removal of the weight of the wearer from the heel, by eway of a non-return valve and a restrictor arranged in series, said trigger valve being adapted and arranged normally to be closed but to permit gas flow through the first passage from said reservoir to the second chamber when the weight of the wearer is placed on the metatarsal heads of the foot.

4. A sole unit as claimed in claim 3, wherein said chambers, passages and passage means are initially filled with gas under pressure.

5. A sole unit as claimed in claim 4, wherein said gas is air at a gauge pressure in the range 1.4 to 2.8 Kg/sq.cm.

6. A sole unit as hereinbefore described with reference to and as illustrated in Figures 1 to 6 or in Figures 1 to 6 as modified by Figure 7 of the drawings.

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